INDOOR AIR QUALITY ASSESSMENT

North Shore Community College
Maude Hall
562 Maple Street, Rte 62
Danvers, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of Richard Reney, Facilities Director for North Shore Community College (NSCC), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at Maude Hall, 562 Maple Street, Route 62 at the NSCC Danvers Campus, Danvers, Massachusetts. The request prompted by mold concerns and poor ventilation as well as occupant complaints of headaches, lethargy and exacerbation of allergies. On April 7, 2005, a visit to conduct an indoor air quality assessment was made to Maude Hall by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by John Edwards, Manager of Buildings and Grounds, NSCC; Dick Passeri, NSCC Facilities Staff and Mr. Reney.

Maude Hall is a two-story brick building that was originally constructed in 1934 as part of the Essex County Agricultural High School (ECAHS) campus. Renovations were made and an addition was built in the mid 1970s. Windows are openable throughout the building. The Commonwealth of Massachusetts reportedly took ownership of Maude Hall in 1999, and the NSCC has used the building since this time. Maintenance responsibilities, however, reportedly are shared between the ECAHS and NSCC. Maude Hall houses the NSCC's cosmetology, nursing and surgical technician classes.

At the time of the assessment, the future of the building was uncertain because of deteriorating conditions of building components. Mr. Reney reported that representatives from the Commonwealth's Division of Capital Asset Management (DCAM) had visited the building in December of 2004 to commission a building assessment/feasibility study. The feasibility study is tentatively scheduled for Summer/Fall 2005. This study should include an assessment of building-wide material/structural needs (building envelope, electrical/wiring, ventilation, occupancy needs, etc).

Methods

MDPH staff conducted air tests for carbon dioxide, temperature and relative humidity with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of water damaged building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe.

Results

Maude Hall has approximately 5-10 faculty members and a student population of up to 80 per day. The tests were taken during normal operations, however due to the intermittent scheduling of classes, a number of the classrooms were unoccupied at the time of the assessment. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in four of fourteen areas surveyed, indicating adequate air exchange in most areas of the building. It is important to note that a number of areas were unoccupied or sparsely populated. Low occupancy can contribute to reduced carbon dioxide levels. Carbon dioxide levels would be expected to increase with full occupancy.

Ventilation in the original portion of the building is provided by a combination of natural gravity vents, open windows and transoms. The natural gravity vents and transoms were sealed throughout the building (Pictures 1 and 2). Exhaust ventilation is provided by wall vents ducted to a wind-driven turbine on the roof (Picture 3). The turbine was observed rotating during the assessment and some draw was detected from the vents in classrooms.

The 1970s portion of the building was designed to have fresh air mechanically supplied to rooms by unit ventilator (univent) systems (Picture 4). A univent draws air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 5) and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). Univents were found deactivated in all areas and appeared not to have been operated for some time. Obstructions to airflow, such as items on top of univents and/or tables and desks in front of univent returns, were also seen in a number of areas. To function as designed, univents must be activated and remain free of obstructions.

Exhaust ventilation was designed to be provided by unit exhaust ventilators (Picture 6), which are much like a univent but remove air *from* the building. A unit exhaust ventilator contains a fan, which draws in and forces air out through an exhaust vent on the exterior of the building (Picture 5). As with the univents, all unit exhaust ventilators were deactivated during the assessment and appeared not to have been operated for some time.

Portions of the building are serviced by a rooftop air handling unit, which provides heating and air conditioning (Picture 7). The AHU was examined by MDPH staff; no intake for the introduction of fresh air could be identified. Therefore it appears that the AHU recirculates air only. Without sufficient supply and exhaust ventilation, environmental pollutants can build up and lead to indoor air quality complaints.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment; however in their current state the systems cannot be balanced.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air for office space, 15 cfm for classrooms or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints.

The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature readings ranged from 70^{o} F to 79^{o} F, which were within or very close to the MDPH recommended comfort guidelines the day of the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. However, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents/exhaust vents inoperable/deactivated and/or obstructed).

The relative humidity measurements in the building ranged from 23 to 30 percent, which were below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth.

MDPH staff examined the outside perimeter of the building to identify potential breaches in the building envelope that could provide a source of water penetration. Several potential pathways for moisture to enter the building were identified, particularly cracks or missing/damaged mortar around exterior brick (Pictures 8 and 9), and rotted wood and spaces around window frames (Picture 10). Over the years, these breaches in the building envelope have resulted in water penetration and staining/damage to building materials (Pictures 11 to 15).

Pictures 13 through 15 show water-damaged plaster and efflorescence. Efflorescence is a characteristic sign of water damage to building materials, but it is not mold growth. As moisture penetrates and works its way through building materials, water-soluble compounds dissolve, creating a solution. As this solution moves to the surface, the water evaporates, leaving behind white, powdery mineral deposits.

In an effort to ascertain moisture content of wall plaster and wooden windowsills, samples were taken in areas where water damage was present. A number of non-effected areas were measured for comparison. As indicated, moisture content was measured with a Delmhorst Moisture Detector equipped with a Delmhorst Standard Probe. The Delmhorst probe is equipped with three lights that function as visual aids that indicate moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. No elevated moisture readings were measured during the assessment (Table 2). In addition, a thorough visual examination of water damaged materials was conducted. These materials include walls, ceilings, ceiling tiles, floors, and stored items. Although, signs of water damage were apparent throughout the building, no visible mold growth or associated odors were observed and/or detected during the assessment.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. Indoor air quality can be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, a number of different odorous materials used in cosmetology (e.g., nail polish/remover, hair dyes, and permanent solutions) would most likely contain VOCs. In an effort to determine whether measurable levels of VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detectable or ND. Although slight odors of cosmetology-related materials could be detected, no measurable levels of TVOC were recorded in the cosmetology area the day of the assessment (Table 1). Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products.

Conclusions/Recommendations

The conditions noted at Maude Hall raise a number of concerns. General building conditions, occupant activities (e.g., the usage of VOC-containing beauty products), exterior structural issues, the condition/age and lack of functioning HVAC equipment and the limited availability of replacement parts, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required. The approach consists of **short-term** measures to improve air quality and **long-term** measures that require planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Contact an HVAC engineering firm to evaluate the operability of mechanical ventilation components
2. Ensure all operable ventilation systems (supply and exhaust) throughout the building are operating continuously during periods of occupancy, but particularly in the cosmetology

area to dilute and remove odors from beauty products. If mechanical ventilation components in the beauty salon are deemed inoperable, consider installing local exhaust ventilation.

3. Use openable windows in conjunction with any operable ventilation components to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.

4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).

5. Continue to work with concerned individuals to identify and address IAQ/mold concerns. Should mold growth occur, clean disinfect or remove mold-contaminated materials in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (US EPA, 2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

6. Contact a masonry firm or general contractor to repair holes/breaches in exterior walls to prevent water penetration, drafts and pest entry.

7. Repair/replace broken windows; re-seal loose window frames as needed to prevent drafts and water penetration.

8. Replace any remaining water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
9. Refer to the resource manual and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These resources are located on the MDPH's website: http://mass.gov/dph/indoor_air.

The comprehensive feasibility study commissioned by DCAM will more likely describe many of the building's needs and provide recommendations for improvement. The following **long-term** recommendations are made as a complement to the feasibility study.

1. Contact an HVAC engineering firm for a full evaluation of the ventilation system and its control system (e.g., pneumatic controls, air intake louvers, thermostats). This measure is strongly recommended, given the age, physical deterioration and availability of parts for the HVAC system
2. Consider having exterior walls re-pointed and waterproofed to prevent water. intrusion. This measure should include a full building envelope evaluation.
3. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames.
4. Contact an HVAC engineering firm for a full evaluation of the ventilation system. Considering the age, physical deterioration and availability of parts of the HVAC system, an evaluation is strongly recommended for proper operation and/or repair/replacement of the ventilation system.

5. Repair and/or replace thermostats and pneumatic controls as necessary to maintain control of thermal comfort. An HVAC engineer can also provide advice concerning the condition and calibration of thermostats and pneumatic controls school-wide.

References

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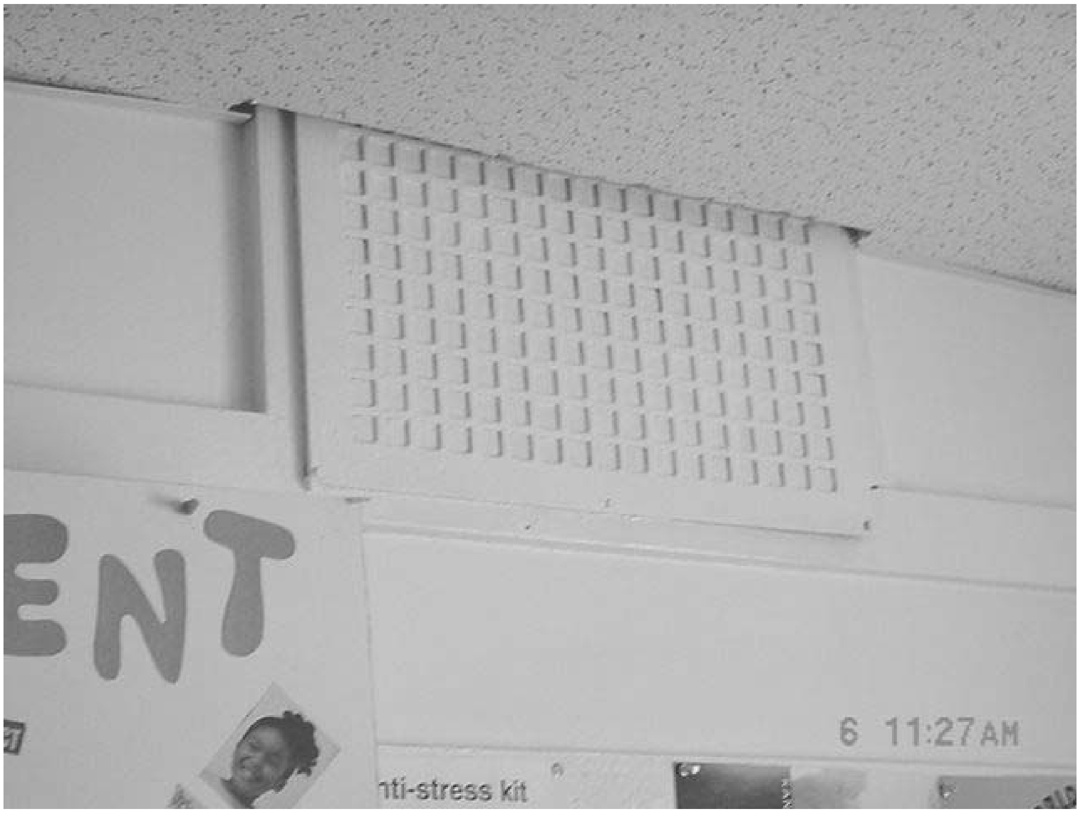
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2001. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

Picture 1



Sealed Gravity Supply Vent

Picture 2

Sealed Transom

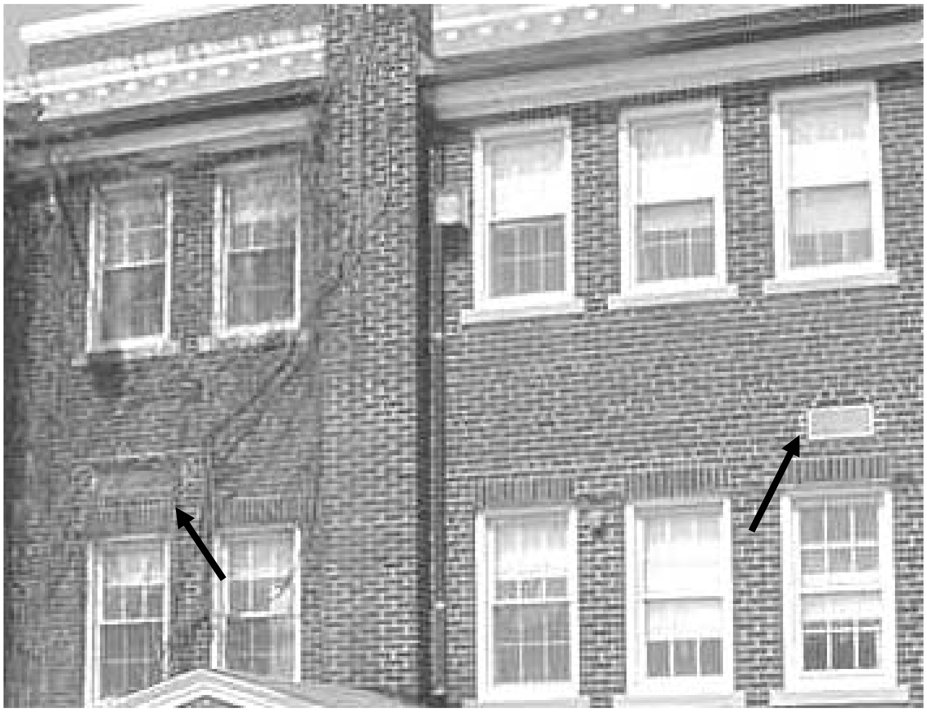
Picture 3

Wind-Driven Exhaust Turbine on Roof

Picture 4

Classroom Univent

Picture 5



Fresh Air Intakes and Exhaust Vents

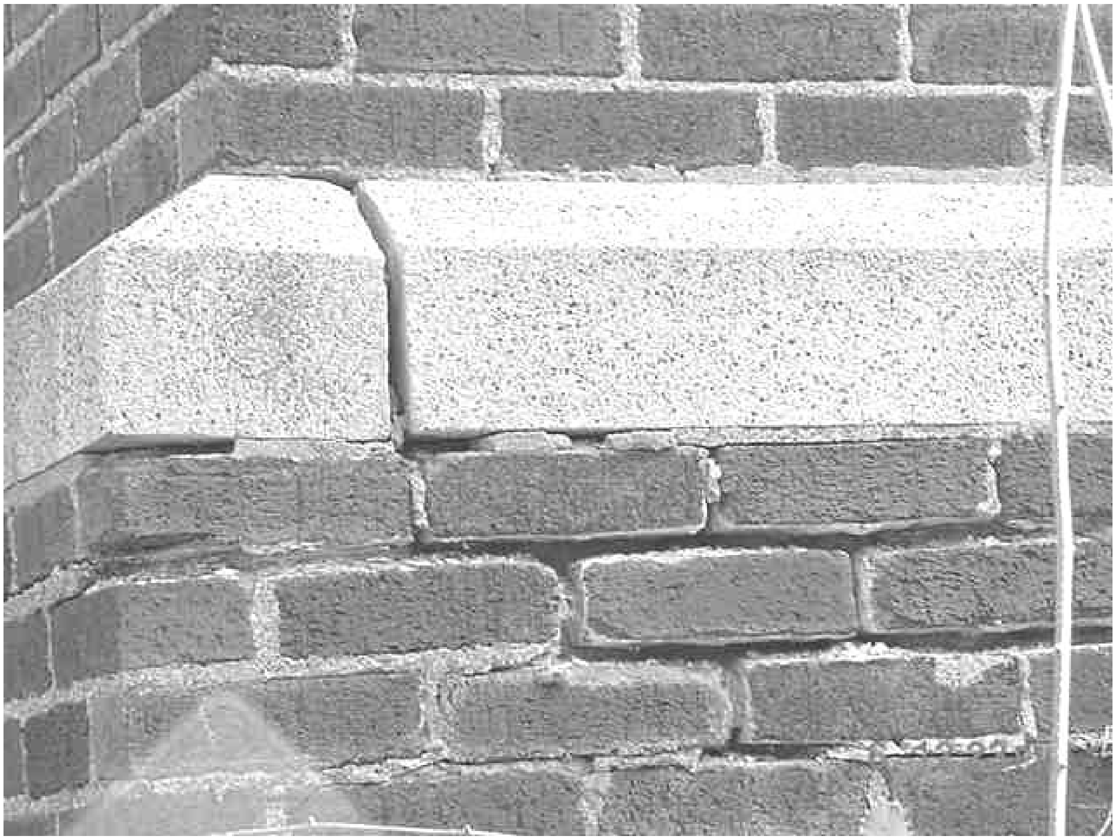
Picture 6

Unit Exhaust Ventilator

Picture 7

Rooftop AHU

Picture 8



Missing/Damaged Mortar around Exterior Brick

Picture 9

Cracked, Missing/Damaged Mortar around Exterior Brick and Window Frames

Picture 10

Rotted Wood, Missing/Damaged Caulking around Window Frames

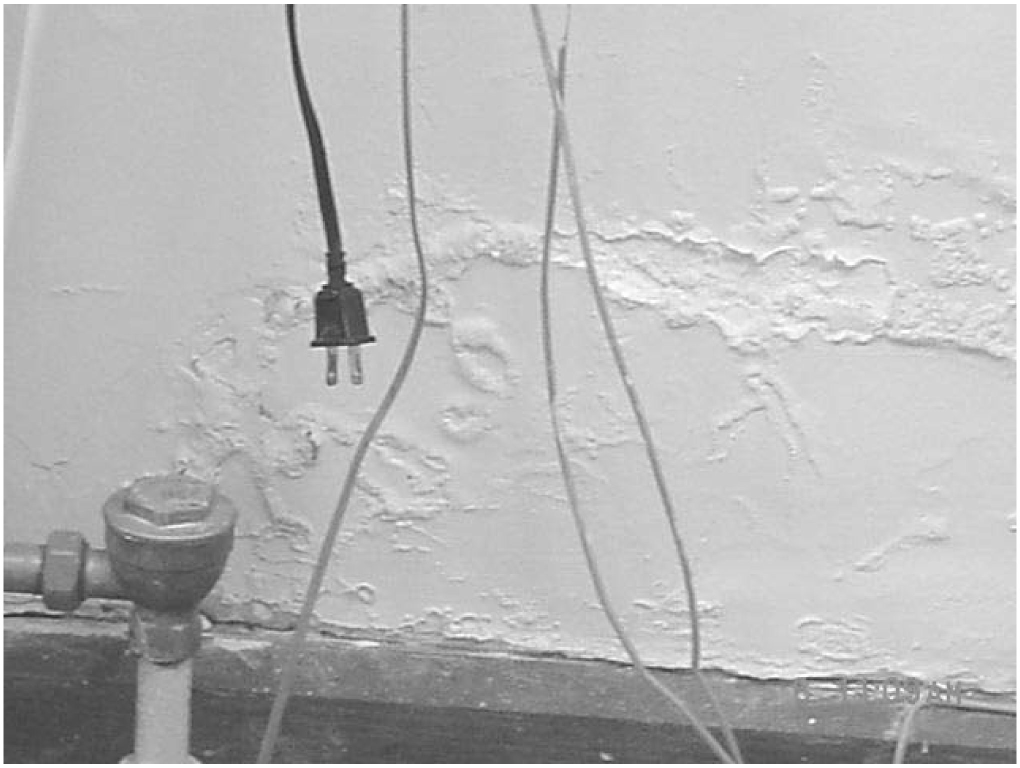
Picture 11

Water Stained Tin Ceiling on Second Floor

Picture 12

Water Stained Tin Ceiling in Basement

Picture 13



Water Damaged Wall Plaster, Efflorescence and Peeling Paint

Picture 14

Water Damaged Wall Plaster, Efflorescence and Peeling Paint

Picture 15

Water Damaged Wall Plaster, Efflorescence and Peeling Paint

TABLE 1

Indoor Air Test Results – North Shore Community College, Maude Hall, Hathorne, MA – April 7, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	TVOCs (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Background	405	60	27	ND					Weather conditions: partly Cloudy, warm, variable winds
215	700	79	24	ND	0	Y	N	Y	Exhaust blocked
201	754	75	24	ND	0	Y	Y	Y	Efflorescence, water damaged wall plaster, Low moisture content
212	750	75	24	ND	0	Y	N	Y	
205	692	75	23	ND	0	Y	N	Y	Efflorescence, water damaged wall plaster, Low moisture content
106B	808	78	25	ND	1	Y	N	N	Wooden windowsills-low moisture
118	1040	78	25	ND	6	Y	Y	N	2 univents-off, water damaged ceiling tiles
124	1106	78	25	ND	0	Y	Y	N	Water damaged ceiling tiles
013	706	77	24	ND	3	Y	N	Y	Missing/dislodged ceiling tiles, efflorescence, water damaged plaster-low moisture, water stained tin roof

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	TVOCs (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
001	808	75	27	ND	8	Y	N	Y	Exhaust vent deactivated
017	613	72	26	ND	3	Y	Y	N	Window open, 2 univents-off, odors from beauty products
021	760	70	29	ND	20	Y	Y		odors from beauty products, exhaust vent could not be located
019	732	71	29	ND	1	N	Y	Y	Water damaged ceiling tiles
009	704	73	30	ND	2	N	Y	Y	
Waiting Room	643	73	28	ND	2	Y	Y	Y	

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